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(54) IMPROVEMENTS RELATING TO CENTRIFUGAL CLUTCHES

(71) We, KOPPERS COMPANY, INC., a corporation organized under the laws of the State of Delaware, one of the United States of America, of 436 Seventh Avenue, City of Pittsburgh, Commonwealtth of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a centrifugal clutch and more particularly to a centrifugal coupling in which torque is transmitted through elastomeric member.

The known centrifugal clutch relies upon centrifugal force for its torque transmission capability. Torque is transmitted from an inner driving hub through a number of engaging shoes to an outer driven drum. The engaging shoes have arcuate friction surfaces that engage the inner cylindrical surface of the outer driven drum and transmit torque from the inner hub to the outer drum. The slip torque capacity of the centrifugal clutch type of coupling is the torque at which slipping of the shoes relative to the outer drum starts. The centrifugal clutch has a slip torque proportional to speed squared and a slip horsepower proportional to speed cubed.

The principal applications of the centrifugal clutch are with engines, reciprocating compressor drives and electric motors where substantially no-load starting conditions are desired. Until the clutch connected to the motor has attained a given speed, little, if any, torque is transmitted to the driven member so that the motor, particularly a squirrel cage electric motor, can accelerate to a speed where it is generating maximum useful torque before the driven member is frictionally engaged through the centrifugal clutch. A centrifugal clutch also provides relatively smooth acceleration of the driven machine because of the slip characteristics of the clutch.

In the past, with the exception of a clutch shown in United States Patent No. 2,588,482, all centrifugal clutches known to the inventor have metal contact between engaging shoes and radially extending portions of the inner hub member. The metal to metal contact between the shoes and the inner hub limits substantially the application of the centrifugal clutch coupling. With metal to metal contact, little, if any, misalignment is possible between the inner hub member and the outer drum member. The cilutch described in Patent No. 2,588,482 has elongated elastomeric bushings that have inner and outer sleeves with an elastomeric annular member bonded to each of the sleeves. The integral bushing is pressed into bored holes in the driven hub member and in the engaging shoe. Steel links connect the inner sleeves to the driving hub and the shoe bushings. With this arrangement there is a direct connection between the driving hub and the engaging shoes with elastomeric annular members between the metallic link connecting the respective members.

The engaging shoes of a centrifugal clutch transmit torque to the outer drum member by means of friction surfaces. The friction force between the engaging shoes and the outer drum member is a function of the centrifugal force which acts upon the engaging shoes when the inner driving hub is rotated. If the line of action of the force transmitted from the inner hub member to the engaging shoes is not normal to a line passing through the centre of gravity of the engaging shoe and its centre of rotation, a servo angle effect between the members is obtained. This results in a radial component of the servo angle acting as an additional force pressing each engaging shoe against the outer drum member. The effective torque is a function of the sum of the radial forces pressing the engaging shoes against the outer drum member.

The present invention relates to a centrifugal clutch comprising an inner hub member adapted for concentric connection with a prime mover and including an outer surface having a plurality of circumferentially spaced vane members extending radially therefrom; an outer drum member coaxially positioned about the said inner hub member, the said outer drum member having an

inner cylindrical surface; a plurality of engaging shoes positioned at equally spaced circumferential intervals between the said inner hub member and the said outer drum member, the said shoes including an arcuate surface coaxially described within the said inner cylindrical surface of the said drum; and elastomeric members positioned between the said inner hub member and the said outer drum member in abutting relationship with the said inner drum member and the said engaging shoes, one of the said inner hub member and the said engaging shoes including a pair of radially extending and axially spaced end flanges arranged to abut the axially spaced ends of the said elastomeric members to maintain the same between the said inner hub member and the said engaging shoes, whereby, upon rotation of the said prime mover, the said inner hub member is operable to transmit torque through the said elastomeric members to the said engaging shoes, the said arcuate surface of the said engaging shoes operable to frictionally engage the said inner cylindrical surface of the said drum and transmit torque from the said engaging shoes to the said outer drum member.

The centrifugal clutch of the invention, having an elastomeric connection between the driving and the driven members, provides torsional resilience and misalignment capacity and permits bi-directional operation where the clutch is capable of transmitting torque in either direction. The centrifugal clutch is also capable of damping torsional vibrations and of providing an added frictional force between the friction surfaces because of the servo angle effect.

The prime mover can be, for example, an electric motor, diesel engine or the like. The outer cylindrical drum member is suitably connected to a driven member such as a gear box, compressor or a pump or the like.

In one embodiment of the invention the inner hub member has a plurality of peripherally spaced radially outwardly extending vanes and the outer drum member has an inner cylindrical engaging surface. A plurality of engaging shoes are positioned between the inner hub and outer drum member. The engaging shoes have an arcuate outer friction surface and an inwardly extending vane member alternately positioned between radially outwardly extending vanes of the said inner hub member. Elastomeric members are positioned between said vane members and are arranged to transmit torque from said inner hub member through the said engaging shoes to said outer drum. The elastomeric members permit misalignment between the hub and drum members, and damp vibrations.

Another embodiment includes engaging shoes having a plurality of inwardly extending vane members. Radially outwardly extending vanes of the inner hub members are alternately positioned with the inwardly extending vanes of the engaging shoes.

Elastomeric members positioned between the alternating vane members can, if desired, be pre-loaded to exert a predetermined force between the hub and shoes. Such preloading force can be varied to control the transmission of torque with respect to the rotational speed of the clutch. Changes in configuration of the hub and the shoes can be used to create either a preload providing higher torque particularly at low revolutions per minute (rpm), or a preload for delaying the transmission of torque until the rpm of the hub member is increased.

The invention will be further illustrated with reference to the accompanying drawings showing by way of example, various embodiments of the invention:

Figure 1 is a view in front elevation and partially in section illustrating for descriptive purposes one of the engaging shoes in a disengaged position and another of the engaging shoes in an engaged position with the elastomeric members therebetween distorted to transmit motion from the driving hub member to the driven drum member,

Figure 2 is a view in section taken along the lines II—II of Figure 1,

Figure 3 is a fragmentary view in front elevation of another embodiment illustrating the positioning means for the elastomeric members secured to and depending from the engaging shoes,

Figure 4 is a top plan view partially in section of the embodiment illustrated in Figure 3, illustrating the manner in which the elastomeric members are substantially enclosed by the engaging shoes,

Figure 5 is a view in front elevation illustrating an engaging shoe having depending end portions with an elongateed elastomeric member secured therebetween and between the radially extending vanes of the inner driving hub member.

Figure 6 is a fragmentary view partially in section of an elastomeric member having bolted end housings,

Figure 7 is a view similar to Figure 6 illustrating another configuration of the elastomeric member with the bolted end housings,

Figure 8 is a partial front elevation of an embodiment illustrating engaging shoes preloaded to cause higher torque particularly at low rpm,

Figure 9 is a partial front elevation of an embodiment illustrating engaging shoes preloaded for delaying the transmission of torque until the clutch rpm is increased,

Figure 10 is a partial front elevation of another embodiment illustrating engaging

shoes preloaded for delaying torque transmission as described in Figure 9, and

Figure 11 is a graph for illustrating the relationship of torque and speed (rpm) as represented by the various embodiments of the invention.

Referring to Figures 1 and 2 there is illustrated a centrifugal clutch, generally designated by the numeral 10, that has an inner hub member 12 and an outer drum member 14 coaxially positioned about the inner hub member 12. A shaft 16 is nonrotatably secured in an axial bore 18 of the inner hub member 12 by means of the key connection 20 to transmit rotation from a prime mover such as an engine, motor or the like through shaft 16 to the inner hub member 12. The outer drum member 14 has a rear plate member 22 with an axial bore 24 therethrough. A driven shaft 26 is nonrotatably connected to the plate 22 by means of the key connection 28. Thus, rotation of the outer drum member 14 transmits rotation through the plate member 22 to the driven shaft 26. As illustrated in Figure 2, the bores 18 and 24 of hub member 12 and outer drum member 14, respectively, are aligned and the shafts 16 and 26 positioned therein are also coaxially aligned. It should be understood, however, as later explained, that coaxial misalignment between the hub 12 and drum 14 may take place without damaging the components and coaxial misalignment of the shafts 16 and 26 is possible while the coupling is transmitting torque from a driving member to a driven member.

The inner hub member 12 has a body portion 30 with a plurality of radially extending vane members 32 terminating in radial edge portions 34. The body portion 30 has an arcuate external surface 36 between the vane members 32. The body portion 30 has a pair of radially extending lateral end flanges 38 and 40 that have a peripheral edge portion 42 in substantial alignment with vane edge portion 34. The end flanges 38 and 40 have a plurality of spaced apertures 44 therein. The apertures 44 in flange 40 are threaded to receive threaded end portions of bolt 46.

The outer drum member 14 has a plate member 22 with a plurality of connecting apertures 48 therethrough. A cylindrical body portion 50 has a radially extending outer flange 52 and an inner cylindrical surface 54. The body portion 50 is coaxially positioned about the inner hub member 12 and has a plurality of bolt apertures 56 that mate with the apertures 48 in plate member 22. Bolts 58 secured the cylindrical body portion 50 to the plate member 22 so that rotation and torque is transmitted through the body portion 50 to plate 22 and shaft 26. If desired, outer drum member 14 and plate member 22 can be provided as a single, unitary member.

Positioned between the inner hub member 12 and the outer drum member 14 are a plurality of engaging shoes, generally designated by the numeral 60, that have an arcuate body portion 62 with a radially inwardly extending vane member 64 and an arcuate external surface 66. A friction facing 68 similar to conventional brake lining is secured to the arcuate outer surface 66. The friction facing 68 is arranged frictionally to engage the inner cylindrical surface 54 of the outer drum member 14. The engaging shoes 60 may be so dimensioned that in a static condition of the driving hub member 12 the friction facing 68 is spaced from the inner cylindrical surface 54 of outer drum member 14. The spacing therebetween is illustrated in the upper portion of Figure 2 and in the upper right quadrant of Figure 1.

The inwardly extending vanes 64 of the engaging shoes 60 extend between the radially outwardly extending vane members 32 of the inner driving hub member 12. Elastomeric members generally designated by the numeral 70 are positoned between the radially inwardly extending vane member 64 and the radially outwardly extending vane members 32. The elastomeric members are fabricated of a flexible material such as natural or synthetic rubber or other polymeric material that exhibits the flexible properties of rubber. The elastomeric member 70 in a relaxed condition as illustrated in the upper right quadrant of Figure 1 and the upper portion of Figure 2 has a generally cylindrical configuration in section with a cylindrical outer surface 72 and an inner axial bore 74. A bolt 46 extends through the aperture 44 in the outer flange member 38, through the axial bore 74 in the elastomeric member 70 and is secured in the threaded bore 44 of flange 40. Washers 76 are positioned between the flange members 38 and 40 and the end portions of elastomeric members 70. With this arrangement the elastomeric members 70 are maintained in position relative to the inner hub member 12 by the radially extending flanges 38 and 40 on the hub member 12 and the flange members 38 and 40 also serve as torque transmitting components. Although the flange members 38 and 40 are illustrated as being integral with the hub member 12, it should be understood they may be separate ring members positioned in overlying relations with the hub member 12 to maintain the elastomeric members 70 properly positioned between the respective adjacent inwardly extending vane 64 and outwardly extending vane 32. As separate rings the positioning members 38 and 40 would not serve as torque transmitting members since in that case the hub vane members 32 transmit the torque.

The flexible clutch coupling 10 above described operates in the following manner. The shaft 16 is driven by a prime mover such as a motor, engine or the like and in turn rotates the inner hub member 12. The rotation of inner hub member 12 is transmitted to the engaging shoes 60 through the elastomeric members 70. The radially extending vanes 32 on the inner hub member 12 transmit torque through the elastomeric members 70 to the inwardly extending vane 64 on the engaging shoes 60. When the inner hub member 12 reaches a pre-determined speed the centrifugal force exerted on the engaging shoes 60 urges the engaging shoes 60 outwardly against the inner cylindrical surface 54 of outer drum member 14 where the frictional surface 68 engages the inner cylindrical surface 54. Above a preselected speed of hub member 12 the torque exerted on hub member 12 by shafts 16 is transmitted through the hub 12, engaging shoes 60 to the outer drum 14 and to the shaft 26 connected thereto. When the inner hub member 12 is transmitting torque to the outer drum 14, the spacing between inner hub vanes and shoe vanes 64 by elastomeric members 70 provides the previously discussed servo angle effect between the driving member and driven member.

Referring to Figures 3 and 4, where similar numerals will designate similar parts, the elastomeric members 70 are maintained in position between the radially outwardly extending vanes 32 on hub member 12 and the radially inwardly extending vanes 64 on the engaging shoes 60 by depending flanges 78 and 80 on the engaging shoes 60. As is illustrated partially in section in Figure 4 and in Figure 3, the elastomeric members 70 are enclosed by the engaging shoes. Torque is transmitted from the inner hub member 12 to the outer drum member 14 in a similar manner as the centrifugal clutch 10 previously described. In the embodiment illustrated in Figures 3 and 4 the radially extending flange members 38 and 40 on the inenr hub member 12 and the elongated bolt members 46 are eliminated. In lieu thereof, radially extending flanges 78 and 80 are provided on the engaging shoes 60.

Referring to Figure 5 there is illustrated an engaging shoe 60 with the depending flanges 78 and 80 discussed in relation to Figures 3 and 4. The depending flanges 78 and 80 have aligned pairs of bolt holes 82 and 84 therebetween. An elastomeric member 86 is positioned between the radially extending vanes 32 of the inner hub member 12 and has a generally elliptical configuration in elevation so that the outer surface 88 of the elastomeric member 86 abuts the external surface 36 of the hub member body portion 30 and the side walls of the radially extending vanes 32. Bolts 90 extend through suitable apertures in the elastomeric material and secure the elliptically shaped elastomeric member 86 to the engaging shoes 60. When the engaging shoe 60 is positioned as illustrated in Figure 5, torque is transmitted from the radially extending vanes 32 through the elastomeric material 86 directly to the shoe body portion 62. The configuration of the elastomeric material 86 as illustrated in Figure 5 eliminates the radially inwardly extending vane member 64 on the engaging shoe 60 and provides for centrifugal engagement between the respective hub and drum members.

In Figures 6 and 7 there are illustrated elastomeric members 92 and 94. The elastomeric member 92 has a generally cylindrical configuration with an integral bore 96. A bolt 98 extends through the cylindrical bore 96 and end housings 100 are connected to the bolt 98 to limit the axial deflection of the elastomeric material under torque transmitting conditions of the coupling. The embodiment illustrated in Figure 7 is similar to that illustrated in Figure 6 in that the elastomeric member 94 has an axial bore 96 with a bolt 98 extending therethrough securing end housings 100 to the elastomeric member 94. The external surface of the elastomeric member 94 is generally barrel shaped as illustrated in Figure 7 in a relaxed condition and distorts when subjected to torque between the inwardly extending vanes 64 and outwardly extending vanes 32 of the coupling 10.

If desired, elastomeric members may be preloaded to exert a predetermined force between the inner hub member 12 and the engaging shoes 60. Such preloading force may be varied to control the initial transmission of torque from the inner hub member 12 to the outer drum member 14 with respect to the rotational speed of the clutch. Changes in configuration between the inner hub member 12 and engaging shoes 60 may be used to create a preload providing higher initial torque at low rpm, as accomplished by the embodiment shown in Figure 8 and graphically illustrated as line A in Figure 11. Also other preload embodiments such as those shown in Figures 9 and 10 may delay the initial transmission of torque between hub 12 and drum 14 until the rpm is increased above a certain value, see line C in Figure 11. Line B, Figure 11, illustrates the non-preloaded condition as shown by the embodiment illustrated in Figure 1 and previously described herein. Torque and rpm value are zero initially. As the RPM value initially increases the torque value will remain zero until the RPM has reached a predetermined value at which point the shoe will engage the inner surface of the drum causing the torque to increase in proportion to RPM squared.

Preloading may be accomplished by forcing oversized elastomeric members 70 in undersized cavities formed between the radially inwardly extending vane members 64 of engaging shoes 60 and the radially outwardly extending vane members 32 of inner hub member 12. However, if desired, elastomeric members 70 may be preloaded due to axial compresison of the members by adjustable means or the like. For example, the configuration shown in Figure 6 may be modified so that when end housings 100 are connected by bolt 98, the axial dimension of elastomeric member 70 is reduced thus increasing the radial dimensions of the elastomeric member to the general configuration shown in Figure 7. In this manner, the desired amount of preload may be substantially controlled and assembly made easier.

Figure 8 illustrates the use of preloading to create initial torque transmission between inner hub member 12 and outer drum member 14 at zero and low rpm. Elastomeric members 70, forced into cavities between alternating hub vane members 32 and shoe vane members 64 urge engaging shoes 60 radially outwardly against inner cylindrical surface 54. Therefore, when prime mover shaft 16 is rotated, inner hub member 12 is operable to transmit torque through elastomeric members 70 to engaging shoes 60 which are already in frictional engagement with the inner cylindrical surface 54 of outer drum member 14. As the rpm value increases, centrifugal force causes increased frictional engagement between engaging shoes 60 and inner surface 54 thus increasing the torque transmitted to outer drum member 14, see line A, Figure 11.

Figure 9 illustrates the use of preloading to create a delay in torque transmission between inner hub member 12 and outer drum member 14 with respect to the rpm of the clutch. Radially outwardly extending hub vane members 32 are arcuately extended to include flange 33 and radially inwardly extending shoe vane members 64 including flange 65. Thus the alternating vanes and flanges form an interlocking configuration generally comprising inner hub member 12 and engaging shoes 60. As a result, when elastomeric memebrs 70 are forced within the cavities created by each hub vane member and the adjacent engaging shoe vane member, the radially opposed flanges 33 and 65 tend to urge engaging shoes 60 radially inwardly away from the inner cylindrical surface 54 of the outer drum member 14. In this manner, no initial transmission of torque occurs between inner hub member 12 and outer drum member 14 since shoes 60 do not contact inner cylindrical surface 54. As the rpm value is increased however, centrifugal force urges engaging shoes 60 into engagement with inner surface 54 and as the engagement force therebetween is increased, torque is eventually transmitted to drum 14, see line C, Figure 11.

Similarly, Figure 10 illustrates an embodiment for utilising preloading to create a delay in torque transmisison between inner hub member 12 and outer drum member 14 with respect to the rpm of the clutch. Radially outwardly extending hub vane members 32 are arcuately extended to include flange 33 and each engaging shoe 60 includes a plurality of spaced radially inwardly extending vane members 64 including flanges 65, as opposed to the single vane members 64 of each engaging shoe 60 shown in previous embodiments. Engaging shoe vane members 64 and hub vane members 32 are symmetrically disposed about inner hub member 12. Thus the alternating vanes and flanges form an interlocking configuration generally comprising inner hub member 12 and engaging shoes 60. As a result, when elastomeric members 70 are forced within the cavities created by each hub vane member and the adjacent engaging shoe members, the radially opposed flanges 33 and 65 tend to urge engaging shoes 60 radially inwardly away from inner cylindrical surface 54 of outer drum member 14 as previously described for the configuration shown in Figure 9, and graphically illustrated as line C, Figure 11.

It will be apparent from the previous description that the centrifugal clutch of the invention reduces or eliminates problems present in centrifugal clutches having metal to metal contact between the respective drive and driven members. The elastomeric members used in the centrifugal clutch of the invention permit misalignment between the components and function to damp vibrations often present.

WHAT WE CLAIM IS:—

1. A centrifugal clutch comprising an inner hub member adapted for concentric connection with a prime mover and including an outer surface having a plurality of circumferentially spaced vane members extending radially therefrom; an outer drum member coaxially positioned about the said inner hub member, the said outer drum member having an inner cylindrical surface; a plurality of engaging shoes positioned at equally spaced circumferential intervals between the said inner hub member and the said outer drum member, the said shoes including an arcuate surface coaxially described within the said inner cylindrical surface of the said drum; and elastomeric members positioned between the said inner hub member and the said outer drum member in abutting relationship with the said inner drum member and the said engaging shoes, one of the said inner hub member and the said engaging shoes including a pair of ra-

dially extending and axially spaced end flanges arranged to abut the axially spaced ends of the said elastomeric members to maintain the same between the said inner hub member and the said engaging shoes, whereby, upon rotation of the said prime mover, the said inner hub member is operable to transmit torque through the said elastomeric members to the said engaging shoes, the said arcuate surface of the said engaging shoes operable to frictionally engage the said inner cylindrical surface of the said drum and transmit torque from the said engaging shoes to the said outer drum member.

2. A centrifugal clutch as claimed in claim 1 wherein each engaging shoe has a radially inwardly extending vane member disposed between adjacent ones of the said inner hub vane members and the elastomeric members are in abutting relationship with adjacent ones of the said engaging shoe vane members and the said inner hub vane members.

3. A centrifugal clutch as claimed in claim 1 or 2 in which the said elastomeric members have a generally elliptical configuration in elevation with a pair of radially spaced axially extending passageways extending therethrough, the said engaging shoes having a pair of axially spaced end flanges formed substantially adjacent the axially spaced ends of said engaging shoes and extending radially inward from the said arcuate surface, the said end flanges including bolt passages therethrough, the said elastomeric members being positioned between the said inwardly extending flanges of the said engaging shoes with the said coaxially extending passageways aligned with the said bolt passages in said end flanges, and bolt members extending through the said aligned bolt passages to secure the said elastomeric members to the said engaging shoes.

4. A centrifugal clutch as claimed in claim 1 or 2 in which the said elastomeric members have a generally cylindrical configuration in elevation, with an axial bolt passageway therethrough.

5. A centrifugal coupling as claimed in claim 1 or 2, in which the said axially spaced end flanges are formed substantially adjacent the said axially spaced ends of the said inner hub member and extend radially outward from the said outer surface.

6. A centrifugal coupling as claimed in claim 1 or 2 in which the said axially spaced end flanges are formed substantially adjacent the said axially spaced ends of the said engaging shoes and extend radially inward from the said arcuate surface.

7. A centrifugal clutch as claimed in claim 5, in which the said axially spaced and radially outward extending end flanges of the inner hub member have a plurality of bolt passages spaced therearound, the said elastomeric members have a generally cylindrical configuration in elevation with an axial bolt passageway therethrough along the length of the said elastomeric member, and having bolt members extending through said passages and axial bolt passageways to secure the said elastomeric members to the said inner hub member so that said elastomeric members transmit torque directly to said engaging shoes.

8. A centrifugal clutch as claimed in any one of the preceding claims in which the said elastomeric members are preloaded to exert a predetermined force between the said inner hub member and the said engaging shoes, whereby the said engaging shoes are urged radially outwardly against the said inner cylindrical surface of the said outer drum member.

9. A centrifugal clutch as claimed in any one of claims 1 to 7, in which the said inner hub member vane members include arcuately extended flange members overlying adjacent ones of the said elastomeric members, the said engaging shoe vane members include arcuately extended flange members underlying adjacent ones of the said elastomeric members substantially opposite the said arcuately extended flange members on the said inner hub member vane members, and the said elastomeric members are preloaded to exert a predetermined force between the said arcuately extended flange members of the said inner hub member vane member and the said arcuately extended flange members of the said shoe vane member for urging the said engaging shoes radially inward away from the said inner cylindrical surface of the said outer drum member.

10. A centrifugal clutch as claimed in claim 1, in which each of the said engaging shoes has a plurality of circumferentially spaced, radially inwardly extending, vane members, the said engaging shoe vane members and the said inner hub vane members are symmetrically disposed about the said inner hub member; and an elastomeric member is positioned between each hub vane member and the adjacent engaging shoe vane member thereby to provide an elastomeric connection between the said inner hub member and the said engaging shoes.

11. A centrifugal clutch as claimed in claim 10, in which the said inner hub member vane members include arcuately extended flange members overlying adjacent ones of the said elastomeric members, the said engaging shoe vane members include arcuately extended flange members underlying adjacent ones of the said elastomeric members substantially opposite the said arcuately extended flange members on the said inner hub member vane members, and the said elastomeric members are preloaded to exert

a predetermined force between the said arcuately extended flange members of the said inner hub member vane member and the said arcuately extended flange members of the said shoe vane member for urging the said engaging shoes radially inward away from the said inner cylindrical surface of the said outer drum member.

12. A centrifugal clutch substantially as described with reference to, and as shown in, any of the accompanying drawings.

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1368130 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

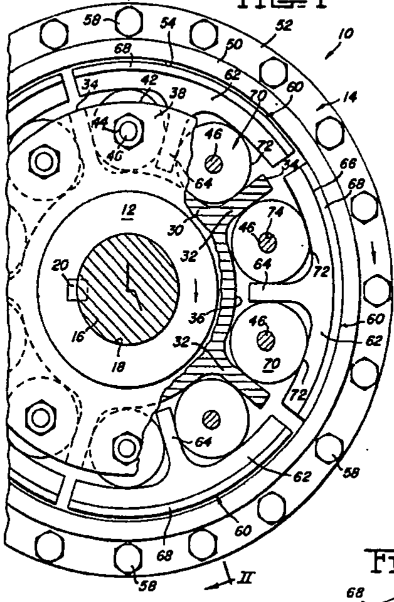


FIG. 2

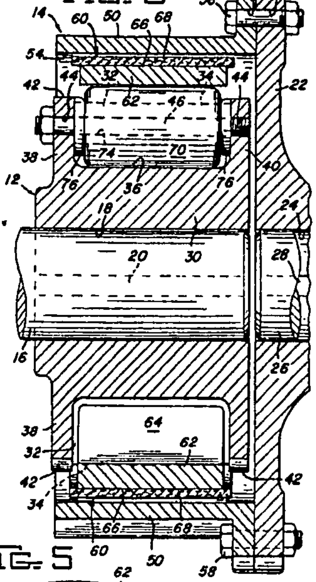


FIG. 5

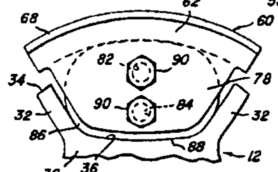


FIG. 4

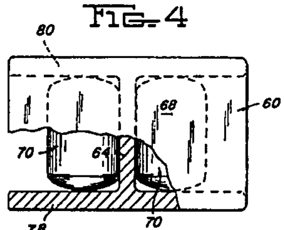


FIG. 6

FIG. 3

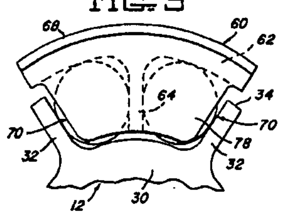
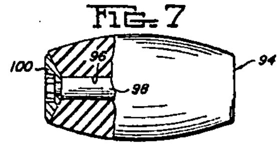


FIG. 7



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Sheet 2

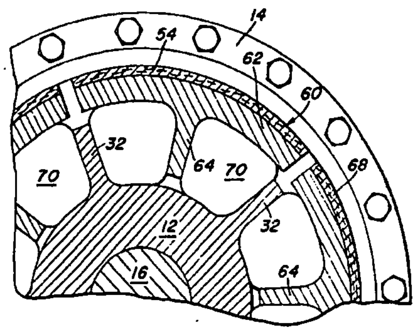

FIG. 8

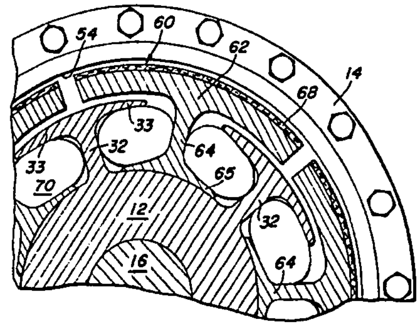

FIG. 9

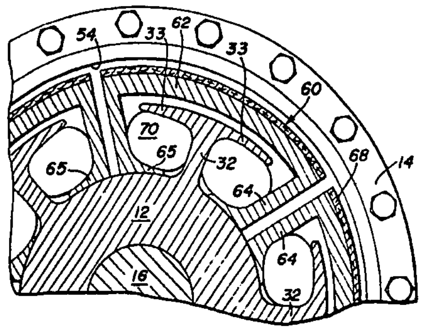

FIG. 10

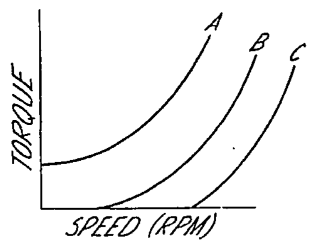

FIG. 11.